DOCUMENT RESUME

ED 254 553 TM 850 164

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TITLE Are Validities Generalizable? An Empirical Assessment.
PUB DATE 2 Apr 85
NOTE 17p.; Paper presented at the Annual Meeting of the American Educational Research Association (69th, Chicago, IL, March 31-April 4, 1985).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Adults; *Cognitive Ability; Error of Measurement; *Job Performance; *Meta Analysis; Personnel Selection; *Predictive Validity; Predictor Variables; Research Methodology; *Test Validity
IDENTIFIERS Employment Service; *General Aptitude Test Battery

ABSTRACT

Drawing from work on the meta-analysis of over 500 validation studies of the General Aptitude Test Battery (GATB) by the U.S. Employment Service, the paper presents a methodological message and a substantive message. Gene Glass's methods, as used by Edwin Ghiselli in personnel selection, ignore study artifacts (sampling error, error of measurement, and range restriction) and lead to a misinterpretation of effect size across studies. Therefore, conclusions on the low predictive power of cognitive testing and the need for local validation are false. Meta analysis has dramatically altered the knowledge from personnel selection studies. Validity (Tables 1 and 2) show that general cognitive ability predicts performance in every job, and better than other pretraining predictors (Table 3). Current job performance predicts future job performance as well as ability (Table 4). While general cognitive ability predicts job performance primarily because it correlates highly with job knowledge, the beta weight indicates ability is also directly related to performance. A detailed, five-page topic outline is appended. (BS)

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ARE VALIDITIES GENERALIZABLE? AN EMPIRICAL ASSESSMENT

John E. Hunter

April 2, 1985

American Educational Research Association

My outline for this paper was 5 pages single spaced. It cannot be presenteed in 20 minutes. I attach it for your later perusal; both to put my present comments in perspective and to provide appropriate references.

However, there are three acknowledgements that I would like to make up front. First, Frank Schmidt has been my co-worker --formal or informal -- on most of this work. Second, Gene Glass has put the case for meta-analysis very forcefully. His general impact means much to me; much more than the problems with his method that I must cite today. I wish it were possible to have critique without criticism. Third, I would like to cite the work done by the U.S. Employment Service. Over 40 years ago, they put together a blue ribbon committee which helped design an aptitude battery -- the GATB -- which is still state of the art. Since then, thousands of USES workers have carried out over 500 validation studies on a wide cross section of jobs from the American economy. This work is the basis for many of the integrative statements that I will make today. I was lucky enough to be the person who did the meta-analysis that harvested the fruit from the tree that they grew. In turn, they have made that meta-analysis the basis for a new program

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of test use for hiring recommendations -- the "validity generaization" or "VG" plan.

I would like to speak to two points today: a methodological message and a substantive message. The methodological message is this: The methods of Gene Glass (Glass, 1976; Glass, McGaw, and Smith, 1981) were put into use in personnel selection over 40 years ago by Edwin Ghiselli and proved to have a fatal flaw. Ignoring study artifacts -- sampling error, error of measurment, and range restriction -- caused Ghiselli (1966,1973) to come to the false conclusions that Frank referred to as the law of situation specific validity. Today I will lay out the quantitative values of those artifacts and show how Ghiselli's error of inference follows from those artifacts.

The substantive message will be much compressed. In a nutshell... As Glass would have predicted, meta-analysis has dramtically altered the amount of knowledge which we have been able to derive from the thousands of studies that have been done on personnel selection. General cognitive ability predicts performance in every job -- see Tables 1 and 2. Other pretraining predictors such as the interview or amount of education or amount of experience are much poorer predictors -- see Table 3. Current job performance will predict future performance in a similar job about as well as ability -- see Table 4. One reason why general cogntive ability predicts performance is that job knowledge is highly correlated with job performance for all jobs -- see Figure 2. Those who don't know the job do poorly at it. General

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cognitive ability predicts how much a person will know about the job and hence predicts performance on the job. However, cognitive ability also predicts performance beyond its contribution to job knowledge. Thus even among workers equal on job knowledge, those with high cognitive ability will have higher performance. This may be due to better application of job knowledge or due to better problem solving in the face of unanticipated problems.

METHODOLOGICAL ARTIFACTS

On page 2 of the outline, under the heading "METHODOLOGICAL ARTIFACTS", there is a list of study artifacts which alter observed study findings from what they should have been. Failure to consider these artifacts leads to a misinterpretation of the variance of effect sizes across studies. Artifacts that can be controlled within a meta-analysis using our methods (Hunter, Schmidt, and Jackson, 1982; Schmidt and Hunter, 1977) are sampling error, error of measurement, and range variation on the independent variable. If enough studies are available, then moderator analysis would permit control of invalidity of selected measures and attrition artifacts. Bad data cannot be controlled in meta-analysis; though we know its there, and we know that the size of the error can be very large. Consider a computer format error which leads to using subject number as a variable rather than cognitive ability. Suppose a correlation is listed with the wrong sign. Typos such as inversion of digits are not likely to be small errors.

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Section II of that outline shows the actual size of these artifacts in personnel selection research. Average sample size is only 68. The average reliability of general cognitive ability is about .80. The reliability of the rating made by a single supervisor is .60 or less. The average degree of range restriction on cogntive ability reduces the ability standard deviation by 33%. The impact of these artifacts is shown in the illustration of Figure 1.

Error of measurement and range restriction systematically reduce the study population correlation from .57 to .28. That is, study artifacts cause the correlation to be underestimated by over 50%. Correction formulas have existed most of this century to eliminate such artifacts, but most of our colleagues regarded correction of errors as "cheating".

Because of the small number of people who work at a given job in a given organization at a given time, sample sizes in personnel selection research are no larger than those of laboratory studies; an average of 68. Thus sampling error spreads the study population correlation over a wide range of observed values. The 95% middle of that range is from .06 to .50. Note that only the extreme sampling errors approach the value of the actual validity. Most values are much lower. In fact, 36% of the correlations will be too small to be statistically significant. That is, 36% of authors will falsely claim the test to be "not valid" in their setting. Meta-anaysis has shown that the significance test is not the answer to the problem of sampling error.

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Like Glass, Ghiselli averaged observed uncorrected correlations to estimate effect size. Thus Ghiselli observed a value of .28 rather than the true value of .57. This lead to his false conclusion that cognitive tests usually have only low predictive power.

Like Glass, Ghiselli took study correlations at face value. Thus he was devastated by sampling error. Like Glass, Ghiselli broke his data down by many potential moderator variables. However, Ghiselli had enough data to disconfirm all the sensible hypotheses. Thus he was lead to the conclusions: (1) that validity is sporadic across settings and (2) that the cause of the variation was too subtle to be detected by current knowledge. This in turn determined his false conclusion that a test should only be used in a given setting after it had been locally validated.

SUBSTANTIVE FINDINGS: VALIDITY OF GENERAL COGNITIVE ABILITY

The principal findings on the validity of general cognitive ability are summarized in Tables 1-4 taken from Hunter and Hunter (1984). In order to facilitate comparisons, job performance has uniformly been measured by supervisor ratings. This is where the data is. However, recent data on work sample measures of job performance suggest that the validity of general cognitive ability is higher if better measures of job performance are used.

Table 1 is a reanalysis of Ghiselli's data. This reanalysis corrects for the systematic sources of error; error of measurement in supervisor ratings and restriction in

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range. However, since Ghiselli didn't publish standard deviations, there is no way to correct them for samping error. The key finding is that validity is very high for many jobs. There is a trend toward lower validity for less complex jobs.

Table 2 presents a summary of the meta-analysis of the USES database on 515 validation studies. The USES had data on job analysis as well as validity. Thus it was possible to measure job complexity. As complexity goes down, the validity of cogntive ability goes down while the validity of psychomotor ability goes up (though the standard deviation of psychomotor validity also goes up). The validity of the optimum ability composite is high across the board.

Table 3 presents the average validity of various predictors in situations where the employee is to be trained after hiring. Ability is far and away the better predictor. Unfortunately, not many studies have looked at more than one kind of predictor. Thus we still don't know how much prediction might be raised by looking at more than one predictor.

Table 4 presents the average validity of measures of current job performance used to predict future job performance in similar jobs. Validity is similar in magnitude to the validity of general cognitive ability.

These tables focus on general cognitive ability rather than specific cognitive aptitudes. Until recently, most psychologists believed that matching specific aptitudes to jobs on the basis of job content would yield better

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prediction than using the same general cognitive ability measure to predict all jobs. The USES data convinced me that this hypothesis is false for most jobs (Hunter, 1980a). This was further confirmed by meta-analyses that I have done on military data the last two years (Hunter, 1983a, 1983b, 1984a, 1984b, 1985). This research is summarized in the outine.

ABILITY, KNOWLEDGE, AND PERFORMANCE

Why does general cognitive ability predict performance in all jobs? An answer to this question emerged out of a meta-analysis that I originally did to find out the validity of job knowledge tests such as those used in civil service programs. I found 14 studies which looked at ability, job knowledge, work sample measures of job performance, and supervisor ratings (Hunter, 1983c). Figure 2 presents the results from this study corrected for restriction in range.

Figure 2 shows that ability is highly correlated with job knowledge and that job knowledge is highly correlated with job performance. The path analysis shows that this indirect causal path accounts for a mojority of the effect of ability onto performance. However, the beta weight for ability net of knowledge is not zero. Thus ability is related to performance itself; not just to jib knowledge. This may be because high ability workers are faster at cognitive operations on the job, are better able to prioritize between conflicting rules, are better able to adapt old procedures to altered situations, are better able to innovate to meet unexpected problems, and are better able

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to learn new procedures quickly as the job changes over time.

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Table 1
Hunter's (1981c) Reanalysis of Ghiselli's (1973) Work on Mean Validity

Job families	Mean validity			Beta weight		
	Cog	Per	Mot	Cog	Mot	*R*
Manager	.53	.43	.26	.50	.08	.53
Clerk	.54	.46	.29	.50	.12	.55
Salesperson	.61	.40	.29	.58	.09	.62
Protective professions worker	.42	.37	.26	.37	.13	.43
Service worker	.48	.20	.27	.44	.12	.49
Trades and crafts worker	.46	.43	.34	.39	.20	.50
Elementary industrial worker	.37	.37	.40	.26	.31	.47
Vehicle operator	.28	.31	.44	.14	.39	.46
Sales clerk	.27	.22	.17	.24	.09	.28

Note. Cog = general cognitive ability; Per = general perceptual ability; Mot = general psychomotor ability; *R* = multiple correlation. Mean validities have been corrected for criterion unreliability and for range restriction using mean figures for each predictor from Hunter (1980c) and King, Hunter, and Schmidt (1980).

Table 2
Relationship Between Ability as Tested by the GATB and Job Performance for Jobs at Five Levels of Complexity

Level	Dimension	Complexity family	% U.S. workers	Mean validity for training success			Mean validity for performance			Regression equation to predict performance			Multiple *R*
				GVN	SPQ	KFM	GVN	SPQ	KFM	GVN	SPQ	KFM	
1	Things	Setting up	2.5	.65	.53	.09	.56	.52	.30	.40	.19	.07	.59
2	Data	Synthesizing/coordinating	14.7	.50	.26	.13	.58	.35	.21	.58			.58
3	Data	Analyzing/compiling/ computing	62.7	.57	.44	.31	.51	.40	.32	.45		.16	.53
4	Data	Comparing/copying	17.7	.54	.53	.40	.40	.35	.43	.28		.33	.50
5	Things	Feeding/offbearing	2.4				.23	.24	.48	.07		.46	.49

Note. Based on data from the U.S. Employment Service (Hunter, 1980c). Dimensions and complexity families from Fine (1955). GVN = cognitive ability; SPQ = perceptual ability; KFM = psychomotor ability; GATB = General Aptitude Test Battery.

Table 3
Mean Validities and Standard Deviations of Various Predictors for Entry-Level Jobs for Which Training Will Occur After Hiring

Predictor	Mean validity	*SD*	No. correlations	No. subjects
Ability composite	.53	.15	425	32,124
Job tryout	.44		20	
Biographical inventory	.37	.10	12	4,429
Reference check	.26	.09	10	5,389
Experience	.18		425	32,124
Interview	.14	.05	10	2,694
Training and experience ratings	.13		65	
Academic achievement	.11	.00	11	1,089
Education	.10		425	32,124
Interest	.10	.11	3	1,789
Age	−.01		425	32,124

Table 4
Mean Validities and Standard Deviations of Predictors to be Used for Promotion or Certification, Where Current Performance on the Job is the Basis for Selection

Predictor	Mean validity	*SD*	No. correlations	No. subjects
Work sample test	.54			
Ability composite	.53	.15	425	32,124
Peer ratings	.49	.15	31	8,202
Behavioral consistency experience ratings	.49	.09	5	
Job knowledge test	.48	.08	10	3,078
Assessment center	.43			

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FIGURE 1
THE IMPACT OF STUDY ARTIFACTS ON PERSONNEL SELECTION RESEARCH

Simplifying assumptions

For simplicity, assume that there is no variation in the validity of general cognitive ability across jobs of medium complexity. Assume that there is no variation in sample size (Average N=68), or the reliability of the ability composite(average = .80), or the reliability of the supervisor rating (maximum = .60), or in the degree of restriction of range (average of u=.67).

Systematic error

I. True validity for all studies: $\rho = .57$

A. Error of measurement in the general cognitive ability measure:

$\rho = .57 \quad ---> \quad \rho = .51$

B. Error of measurement in supervisor ratings:

$\rho = .51 \quad ---> \quad \rho = .40$

C. Range restriction on ability in the incumbent population:

$\rho = .40 \quad ---> \quad \rho = .28$

D. All told, the study population correlation is reduced by over 50%:

$\rho = .57 \quad ---> \quad \rho = .28$

Sampling error

A. For N=68, the sampling error standard deviation is:
$\sigma_e = .11$

B. The 95% midrange is
$.06 < r < .50$

C. The value required for statistical significance is .24.
P(test is labeled "not valid") = 36 %.

Ghiselli's false conclusions

1. Law of situation specific validity -- The validity of a given test for a given job varies from one setting to the next because of subtle organization differences.
2. Tests usually have only low predictive power.
3. A test should be used in a given setting only after it has been assessed by a local validation study.

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FIGURE 2. COGNITIVE ABILITY, JOB KNOWLEDGE, JOB PERFORMANCE, AND SUPERVISOR RATINGS

Definition of variables

A = Ability : General cognitive ability -- that factor which explains the high correlations between different cognitive aptitudes (primary factors) and between achievement in diverse areas -- estimated by a composite across various aptitudes such as quantitative and verbal aptitude

JK = Job Knowledge -- a content valid (based on job analysis) measure of job knowledge

WS = Job Performance -- a content valid (based on job analysis) work sample measure of job performance -- performance at work stations where performance can be objectively measured

SR = Supervisor Ratings -- supervisor ratings of job performance -- correlations are corrected for interrater reliability so these ratings are free of both random response error and halo

Correlations

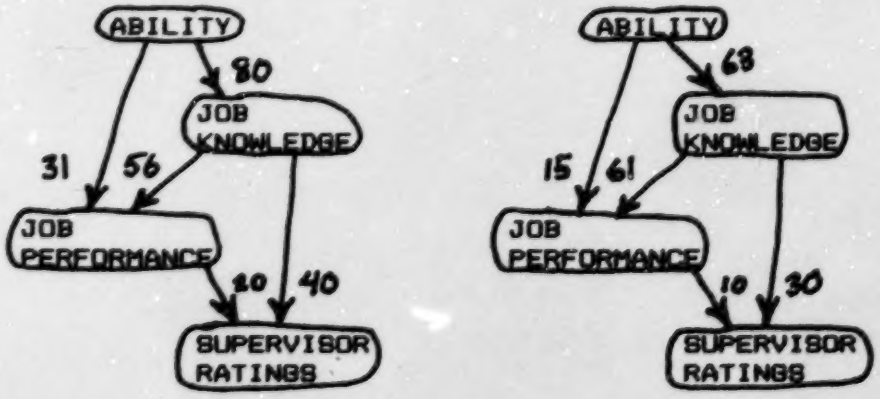
Civilian (N=1790)				Military (N=1474)			
A	100			A	100		
JK	80	100		JK	63	100	
WS	75	80	100	WS	53	70	100
SR	47	56	52 100	SR	24	37	31 100

Multiple Correlations:

R for WS : 82 — R for WS : 71

R for SR : 57 — R for SR : 38

Path analyses



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ARE VALIDITIES GENERALIZABLE? AN EMPIRICAL ASSESSMENT

John E. Hunter

April 2, 1985

American Educational Research Association

OUTLINE

I. Historical background
II. Methodological artifacts
III. Empirical findings
IV. Cognitive ability, job knowledge, and job performance

HISTORICAL BACKGROUND

I. 1914-present : Thousands of individual studies on all characteristics ever recomended for use in selecting employees; cognitive tests, the interview, education, handwriting analysis, etc.
II. Ghiselli's work: 1949-1973
   A. Cumulation of validation studies using the methods subsequently rediscovered by Glass(1976)
   B. False conclusions:
      1. Law of situational specificity of validity — The validity of a given test for a given job varies from one setting to another because of subtle organizational differences
      2. Tests usually have only low predictive power
      3. A test should be used in a given setting only after it has been assessed by a local validation study
III. Schmidt and Hunter (1977)
   A. Critique of Ghiselli for failure to consider study artifacts; especially sampling error
   B. Specification of "validity generalization" — a method of meta-analysis which controls for sampling error, error of measurement of job performance, and range restriction on the predictor.
IV. Subsequent results
   A. Validity of cognitive tests
      1. Review: Schmidt and Hunter(1981) — about 500 studies of particular test-job combinations have shown that there is little variation in validity across settings or across time. Ghiselli's law of situational specificity was the result of failing to correct for the impact of sampling error on the variance of results across studies.
      2. The U.S. Employment Service database — 515 validation studies on the GATB — Hunter's reanalysis (Hunter,1980a,1980b,1981a,1981b; Hunter and Hunter, 1984).
         a. General cognitive ability predicts performance on all jobs.
         b. Validity is higher for complex jobs than for simple jobs.
      3. Reanalysis of Ghiselli (Hunter,1981c; Hunter and Hunter, 1984). The impact of error of measurement of job performance and restriction in range on

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ability is much greater than Ghiselli thought.

B. Fairness and utility of cognitive tests
   1. Fairness -- Reviews: Hunter, Schmidt, and Rauschenberger (1984) -- Cognitive tests do NOT understate the aptitude of minorities.
   2. Utility -- Reviews: Hunter and Schmidt (1983). Selective organizations can increase productivity by 20% hiring from the top down on general cognitive ability.

C. Validity of other predictors--Hunter and Hunter(1984)
   1. For jobs where selection precedes training, the validity of ability is far higher than any known alternative.
   2. For promotion or other situations where the person is already doing essentially the same job, current job performance measures predict as well as ability.

D. General cognitive ability versus specific cognitive aptitudes in the prediction of job performance
   1. Schmidt and Hunter (1978) -- perfect correlation of validities across jobs
   2. Hunter (1980a) -- Reanalysis of the USES database
      a. General cognitive ability has higher validity than specific aptitudes for all jobs
      b. For most jobs, specific aptitudes predict performance only because they are correlated with general cognitive ability
   3. Military research -- Hunter (1983a,1983b,1984a, 1984b,1985) -- Confirmation of USES findings --

E. General developments
   1. Generalized meta-analytic methods -- Hunter, Schmidt, and Jackson (1982)
   2. Criticisms of validity generalization -- Schmidt, Hunter, Pearlman, and Hirsch(in press)
   3. Cognitive ability, job knowledge, and job performance -- Hunter (1983c,1984b) -- see below

METHODOLOGICAL ARTIFACTS

I. General artifacts
   A. Artifacts that can be controlled within meta-analysis
      1. Sampling error
      2. Error of measurement in the independent variable
      3. Error of measurement in the dependent varriable
      4. Range variation in the independent variable
   B. Artifacts that may or may not be controllable within meta-analysis -- the key question being whether enough studies are present. It does not take an enormous number of studies for meta-analysis to show that artifacts are not there. However, if one of these artifacts is there, it may take many studies to provide for an adequate moderator analysis to delineate that effect.
      1. Invalidity in one or more measures of the independent variable

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2. Invalidity in one or more measures of the dependent variable
   -- in personnel selection, this problem is known as contamination or deficiency of the criterion
3. Attrition artifacts
   -- in personnel selection, quitting, firing, and promotion can produce restriction in range on the dependent variable as well as the dependent variable

C. Artifacts which cannot be controlled within meta-analysis
   1. Bad data
      a. Errors in coding raw data
      b. Errors in setting up computer runs
      c. Errors in transcribing computer results
      d. Errors in typing tables
      e. Errors in printing tables
      Note: errors due to bad data can be very large as with errors of algebraic sign of correlations

II. Artifacts in validation studies on cognitive aptitude tests : the magnitude of artifacts in the study of the prediction of job performance using general cognitive ability
   Note: This presentation will consider only general cognitive ability. Similar analyses have been done for specific aptitudes and for other predictors such as the interview, reference checks, amount of education, etc.
   Note: For simplicity, this presentation will ignore variation in sample size, variation in reliability, and variation in range restriction.
   1. Validity of general cognitive abiility
      For a job of medium complexity, the average correlation between true score general cognitive ability and consensus supervisor ratings is .57 (Hunter,1980b; Hunter and Hunter,1984)
      Assume this is constant across studies for purposes of illustration.
   2. Magnitude of study artifacts
      a. Sampling error -- the average sample size in personnel research is 68 (Lent, Aurbach, and Levin 1971)
      b. Predictor unreliability -- the coefficient of generalizability for the cognitive composite on the GATB is .80 (Hunter, 1980a)
      c. Criterion unreliability -- Even for perfect measurement of the impressions of a single supervisor, the interrater reliability is only .60 (King, Hunter, and Schmidt, 1980)
      d. Range restriction -- across 425 validation studies done by the USES, the average level of range restriction on general cognitive ability was u=.67 (Hunter,1980b; Hunter and Hunter, 1984)
   3. Impact of artifacts
      a. Systematic effects
         (1)Operational validity -- error of measurement

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of general cognitive ability reduces validity from .57 to .57 .80 = .51
Note: since prediction is done with the imperfect test, this is the validity for the applied setting.
(2) Imperfect performance measurement -- validity is reduced from .51 to .51 .60 = .40
(3) Range restriction -- restricted hiring reduces the observed standard deviation on the independent variable by one third and reduces the validity from .40 to .28
(4) Combined -- all told, study artifacts reduce validity from a true value of .57 to a study population value of .28.

b. Nonsystematic effects -- sampling error
(1) The study population value is not .57 but .28
(2) Sample size is 68
(3) Thus the standard deviation of validity across studies is .1126. The middle 95% of studies will vary from .06 to .50
(4) The correlation required for statistical significance is .24. Thus, 36% of studies would report "test not valid".

c. Total impact
(1) Ideal studies -- all report a validity of .57
(2) Actual studies -- validity spreads across a wide range: a mean of .28 and a standard deviation of .11 -- 36% report "not valid"
(3) Conclusion -- Ghiselli falsely concluded that validity is situation specific

III. Other cognitive tests -- specific cognitive aptitudes have lower true validity and lower reliability as well -- observed studies falsely look even more sporadic

EMPIRICAL FINDINGS

I. General cognitive ability -- see Tables 1 and 2 -- operational validity varies from .23 for low complexity jobs to .58 for high complexity jobs

II. Specific cognitive aptitudes
A. Specific cognitive aptitudes have lower validity than general cognitive ability
B. For most jobs, specific aptitudes contribute to prediction only because they are correlated with general cognitive ability. Partial correlations are usually 0.

III. Other abilities
A. Psychomotor ability (hand eye coordination) -- see Tables 1 and 2 -- low validity for complex jobs, high but variable validity for simple jobs
B. Social ability -- demonstrated through assessment centers for management jobs, though it cannot yet be measured independently of cognitive ability

IV. Predictors other than cognitive aptitude
A. Pretraining predictors -- see Table 3 -- much lower validity than general cognitive ability
B. Performance at same or near same job -- see Table 4

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-- validity at about the same level as cognitive ability

COGNITIVE ABILITY, JOB KNOWLEDGE, AND JOB PERFORMANCE

I. Questions
  A. Why does general cognitive ability predict performance for all jobs?
  B. How valid are supervisor ratings as assessments of job performance? -- Note: this question applies to perfect ratings free of error of measurement

II. Research base
  A. Primary meta-analysis -- Hunter (1983c)
  B. Research base -- 14 studies with data on at least 3 of 4 critical variables: ability, job knowledge, work sample measure of job performance, and supervisor ratings
  C. Research contexts
    1. Performance appraisal -- the relevant population is the incumbent population and correlations need not be corrected for restriction in range on ability -- the case considered in Hunter (1983c)
    2. Personnel selection -- the relevant population is the applicant population and all correlations must be corrected for restriction in range -- see Figure 1

III. Findings
  1. Work sample job performance is highly correlated with job knowledge -- people who do not know the job do poorly at the job
  2. General cognitive ability is highly correlated with job knowledge -- low ability people learn more slowly
  3. Thus one reason why cognitive ability predicts job performance is that cognitive ability predicts job knowledge -- This indirect effect of ability explains .45 of the correlation between ability and performance i.e. .45 of .75
  4. The beta weight for ability predicting performance net of knowledge is .31 -- ability makes an independent contribution to job performance
     -- This may mean that high ability workers are
     a. Faster at the cognitive operations on the job
     b. Better able to prioritize between conflicting rules
     c. Better able to adapt old procedures to altered situations
     d. Better able to innovate to meet unexpected problems
     e. Able to learn new procedures more quickly as the job changes over time
  5. Supervisor ratings are correlated only .52 with work sample measures of job performance even after correction for attenuation due to halo and random response error.
     -- This may mean that supervisor ratings are strongly effected by personal characteristics that are not related to job performance.

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